

Impacts of oyster cultures on nitrogen budgets in Hiroshima Bay, the Seto Inland Sea of Japan

The 33rd UJNR Aquaculture Panel Symposium
Ecosystem and carrying capacity of aquaculture ground
-for the sustainable aquaculture in harmony with nature-

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Inland Sea**



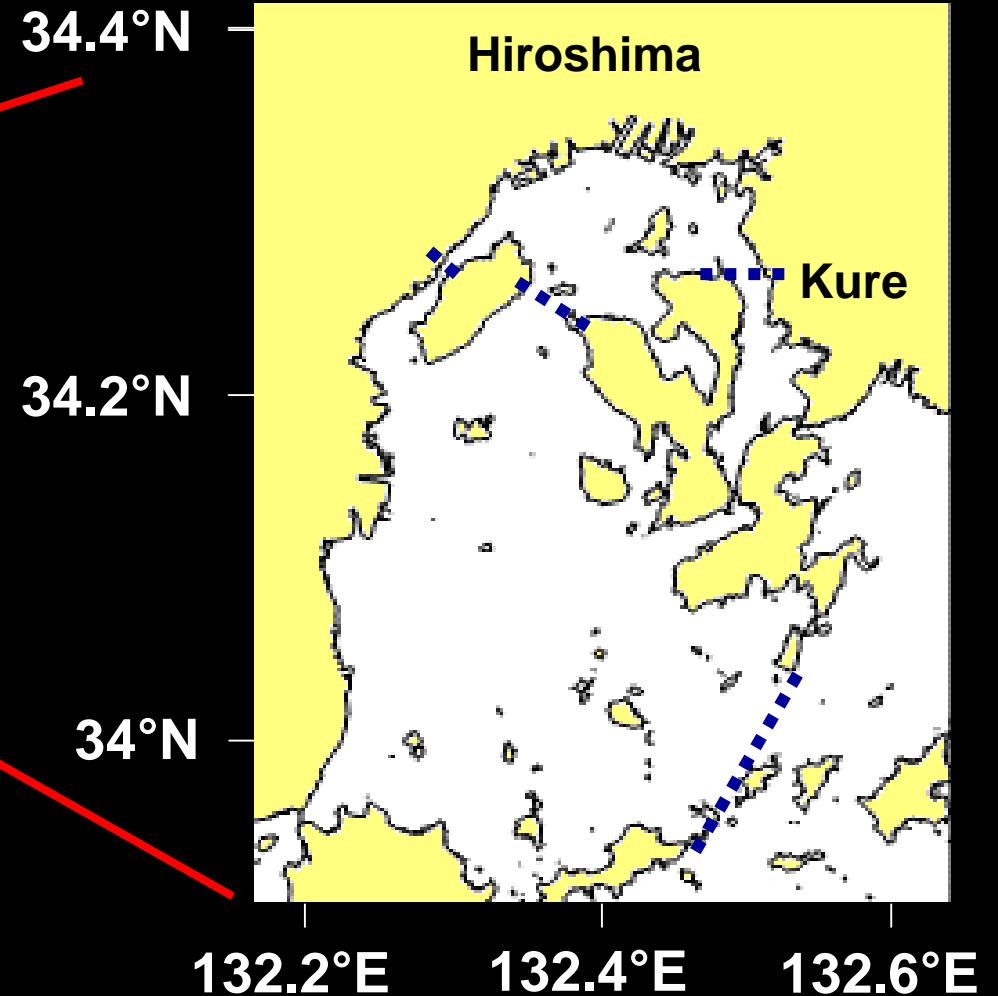
Outline

- ◆ **Nitrogen budgets in Hiroshima Bay**
- ◆ **Impacts of oyster cultures on nitrogen budgets in Hiroshima Bay**
 - (1) Filtering activity of phytoplankton particulate nitrogen by oyster cultures
 - (2) Removal efficiency of nitrogen from the bay by oyster cultures

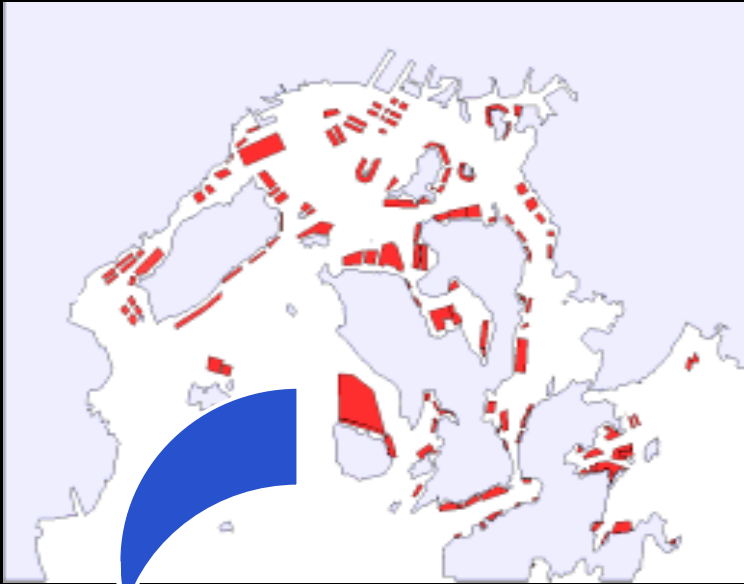
Hiroshima Bay?



Surface area: ca. 1000 km²
Mean water depth: ca. 25 m

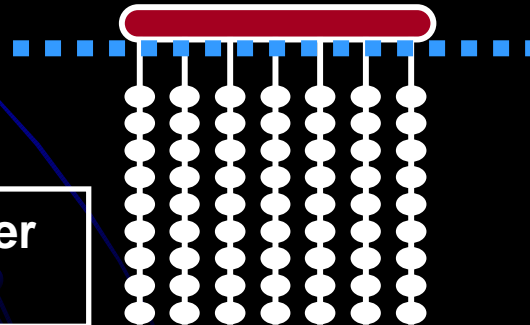


Oyster cultures in Hiroshima Bay



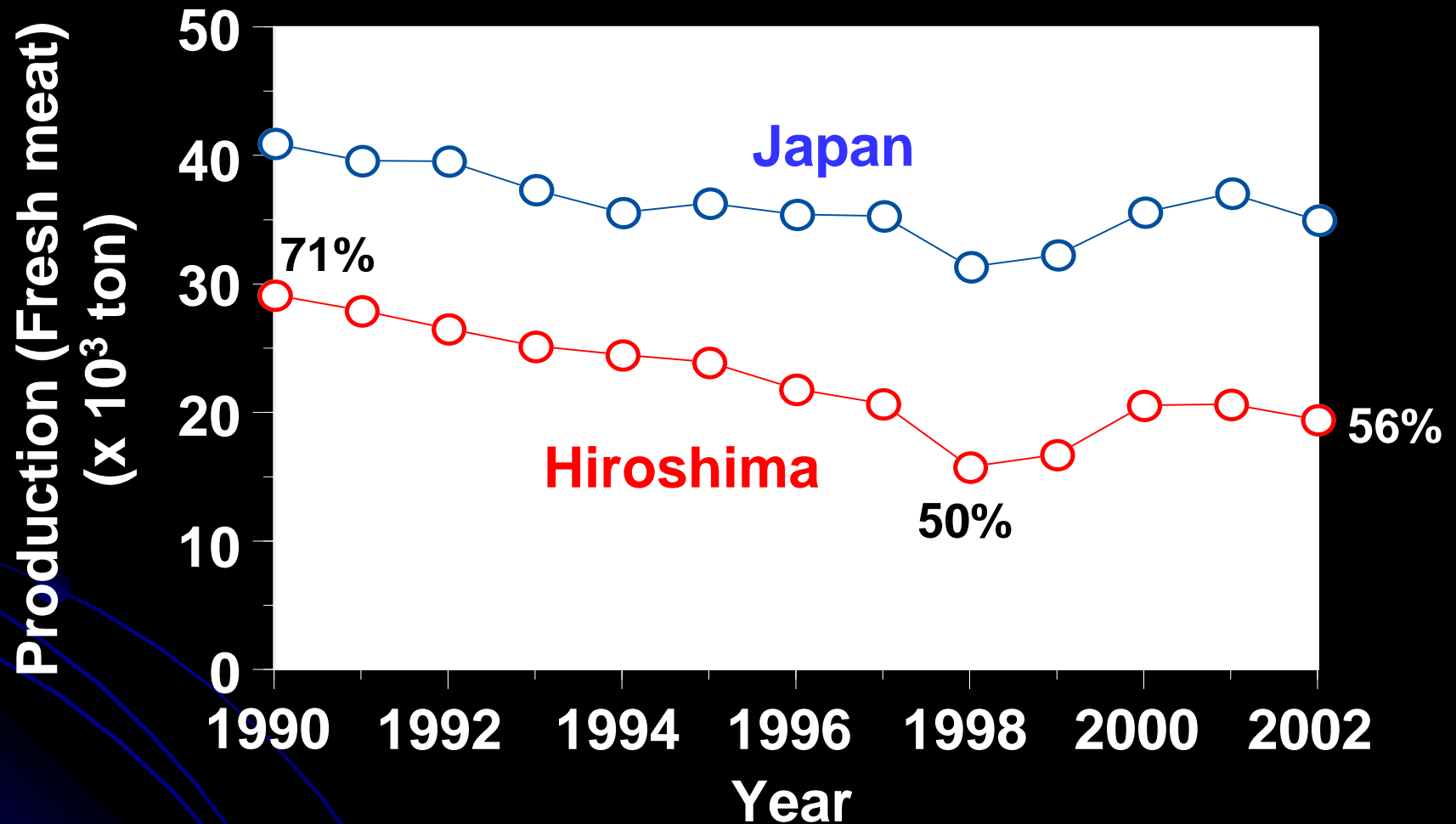
Oyster culture area in Hiroshima Bay
(referred from www.suisansc.or.jp)

Hanging method under
a floating raft



(referred from www.chugoku-np.co.jp)

Oyster production in Japan



Changes in the production of oyster cultures in Japan and Hiroshima Prefecture through 1990 – 2002.

Methods

- **Study area**

Northern Hiroshima Bay

- **Study period**

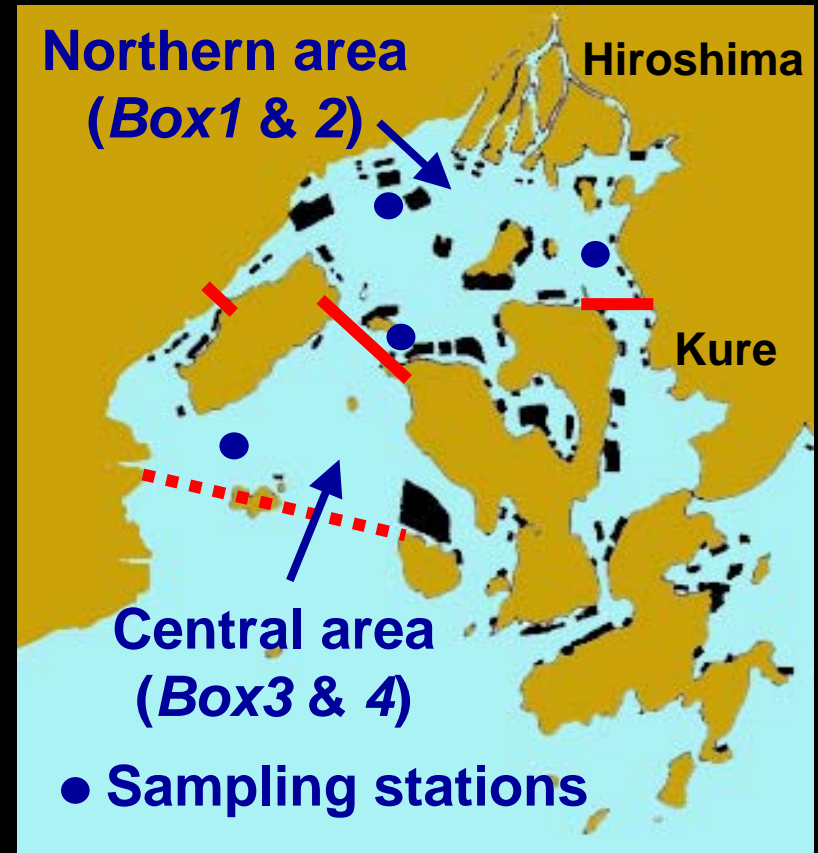
Jan – Dec 2001

- **Observations**

Water temperature, Salinity
Dissolved inorganic nitrogen
(nitrate, nitrite and ammonium)
Dissolved organic nitrogen
Particulate organic nitrogen
Chlorophyll a, Primary production

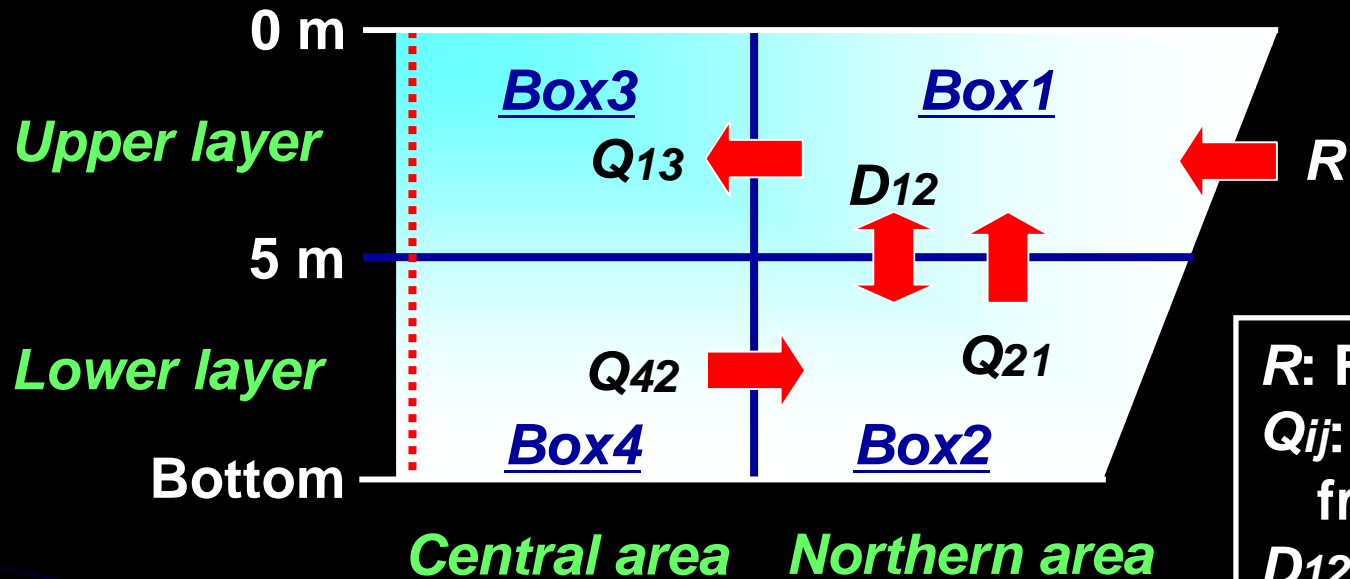
- **Other data**

River flow (Ministry of Land,
Infrastructure and Transport)
Nitrogen concentration in rivers
(Hiroshima Prefecture)
Sewage outflow, nitrogen
concentration (Hiroshima City)
Precipitation, Air temperature
(Japan Meteorological Agency)



Study area and sampling stations in Hiroshima Bay. Box dimensions for the model are also given.

Box model analysis



R : Freshwater inflow
 Q_{ij} : Convective flows from $Box(i)$ to $Box(j)$
 D_{12} : Vertical turbulent diffusive flow between $Box1$ and $Box2$
 V_i : Volume of $Box(i)$
 S_i : Salinity in $Box(i)$

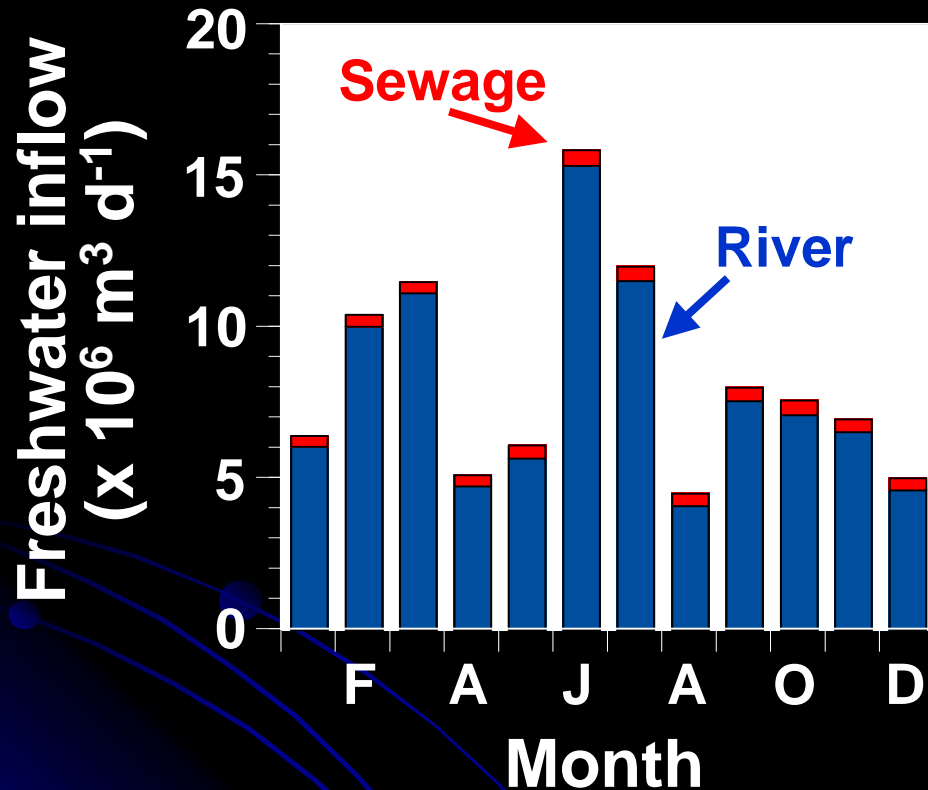
$$R + Q_{21} - Q_{13} = 0$$

$$V_1(dS_1/dt) = S_2 Q_{21} + D_{12}(S_2 - S_1) - S_1 Q_{13}$$

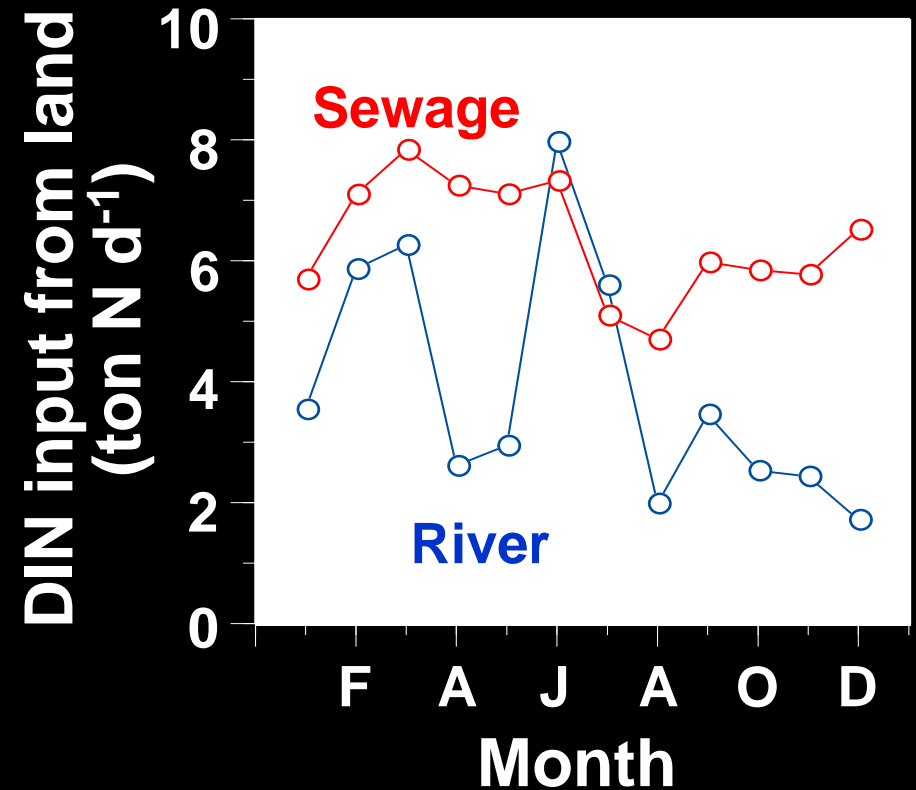
$$Q_{42} - Q_{21} = 0$$

$$V_2(dS_2/dt) = -S_2 Q_{21} + D_{12}(S_1 - S_2) - S_4 Q_{42}$$

Seasonal variations of freshwater inflow and nitrogen input from land

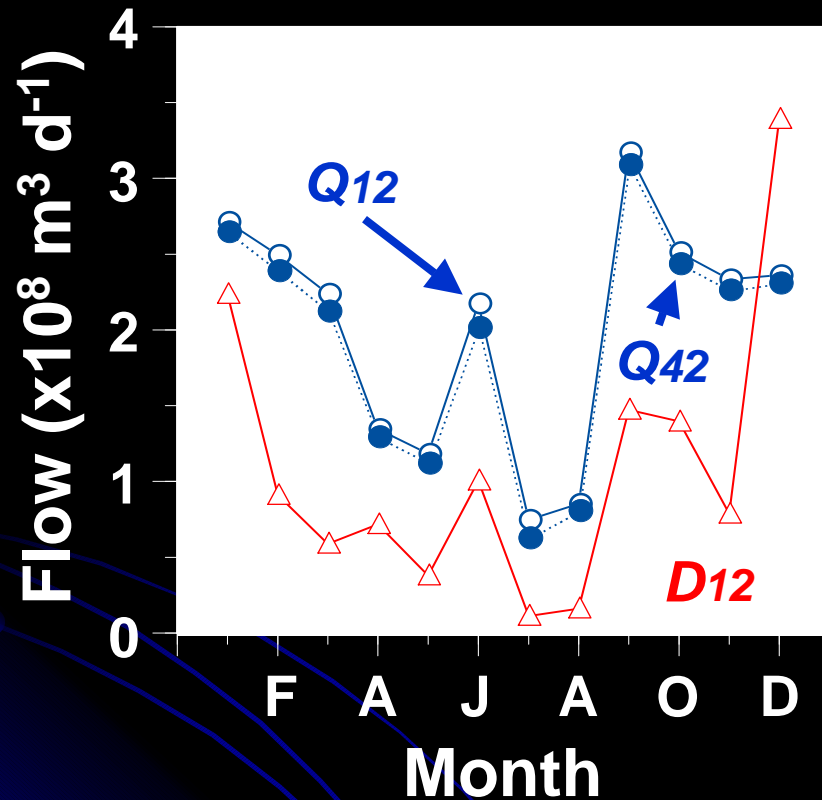


Time series of freshwater flow to northern Hiroshima Bay through Jan – Dec 2001.

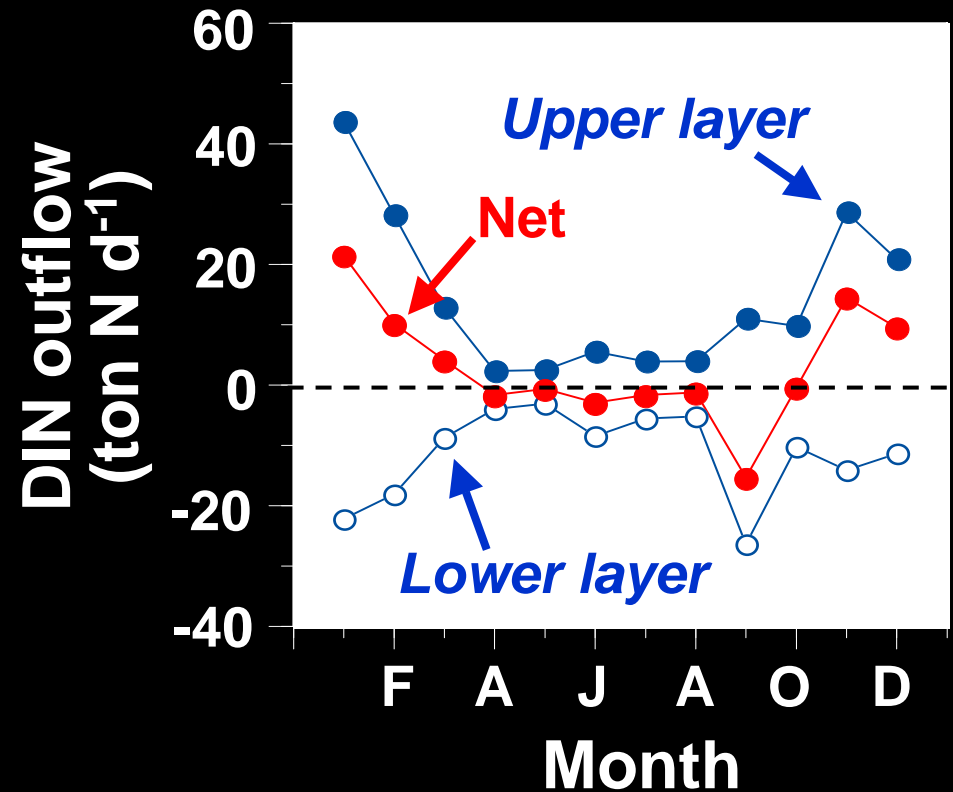


Time series of dissolved inorganic nitrogen (DIN) input from land to northern Hiroshima Bay through Jan – Dec 2001.

Seasonal variations of flows and nitrogen outflow in northern Hiroshima Bay



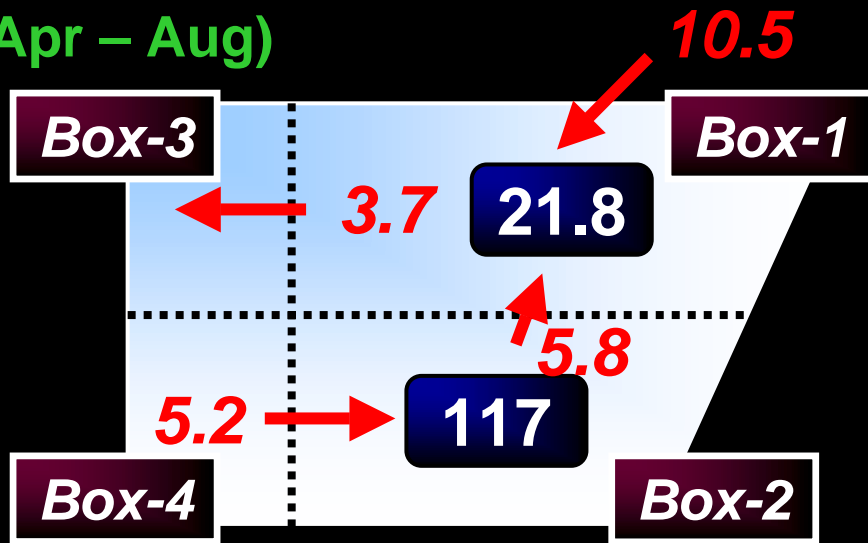
Time series of convective (Q_{12} and Q_{42}) and vertical diffusive flows (D_{12}) through Jan – Dec 2001.



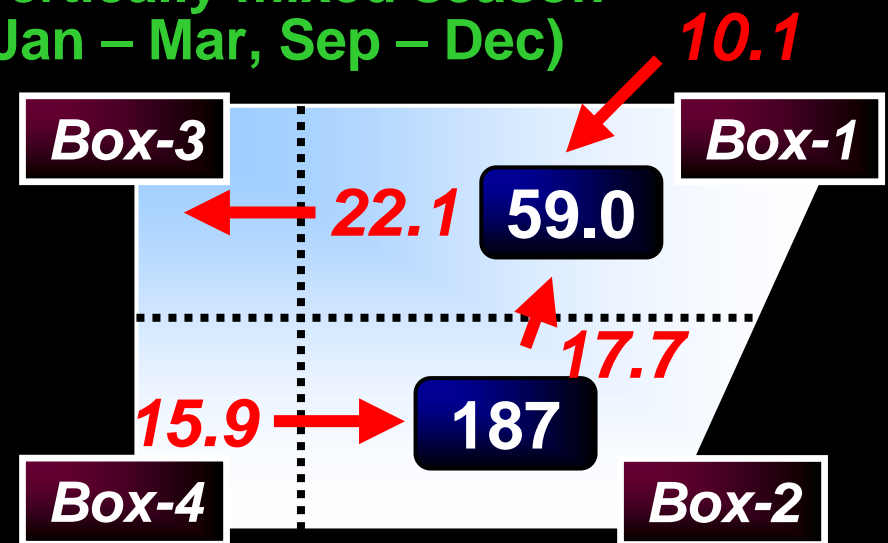
Time series of DIN outflow from northern part to central part of Hiroshima Bay through Jan – Dec 2001.

DIN budgets in northern Hiroshima Bay

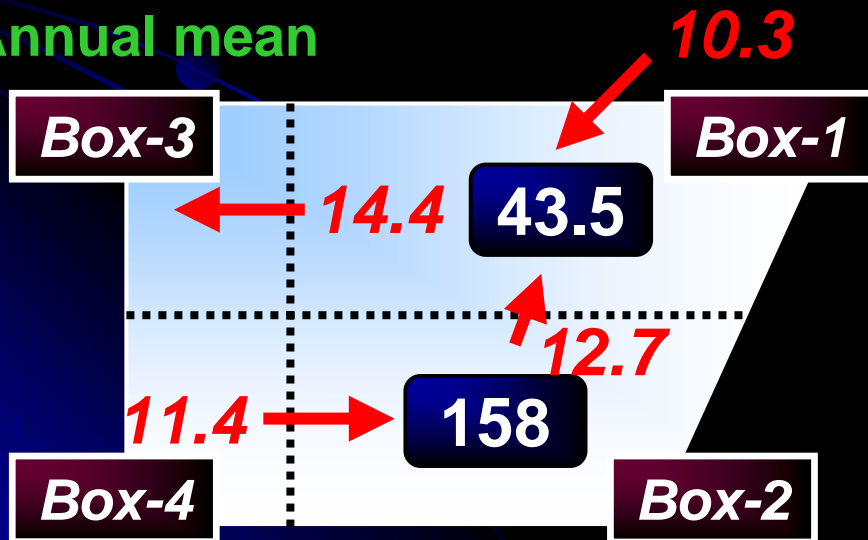
Stratified season
(Apr – Aug)



Vertically mixed season
(Jan – Mar, Sep – Dec)



Annual mean



Units:

Standing stock (frame) = ton N

Flux (arrow) = ton N d⁻¹

Filtering activity of phytoplankton particulate nitrogen by oyster cultures

Micro-
zooplankton

Net-zooplankton

Filtration rate
(ton N d⁻¹)

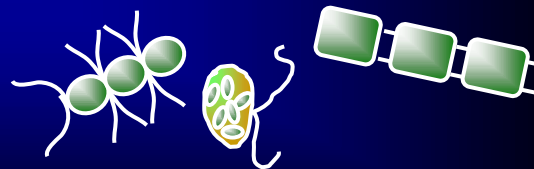
2.4

4.0

7.3

Oyster culture

Production:
35.6 ton N d⁻¹
Biomass:
91 ton N



Phytoplankton

Annual mean values of filtration rates for micro-zooplankton, net-zooplankton and oyster cultures in northern Hiroshima Bay

Removal efficiency of nitrogen from the bay by oyster cultures

Oyster cultures

Annual production:
20640 ton (fresh meat)

↓ 1.24%

250 ton N
0.68 ton N d⁻¹

Fisheries

Annual catches: 5030 ton

↓ 1.1%

55 ton N
0.15 ton N d⁻¹

6.6% (DIN)
4.6% (TN)

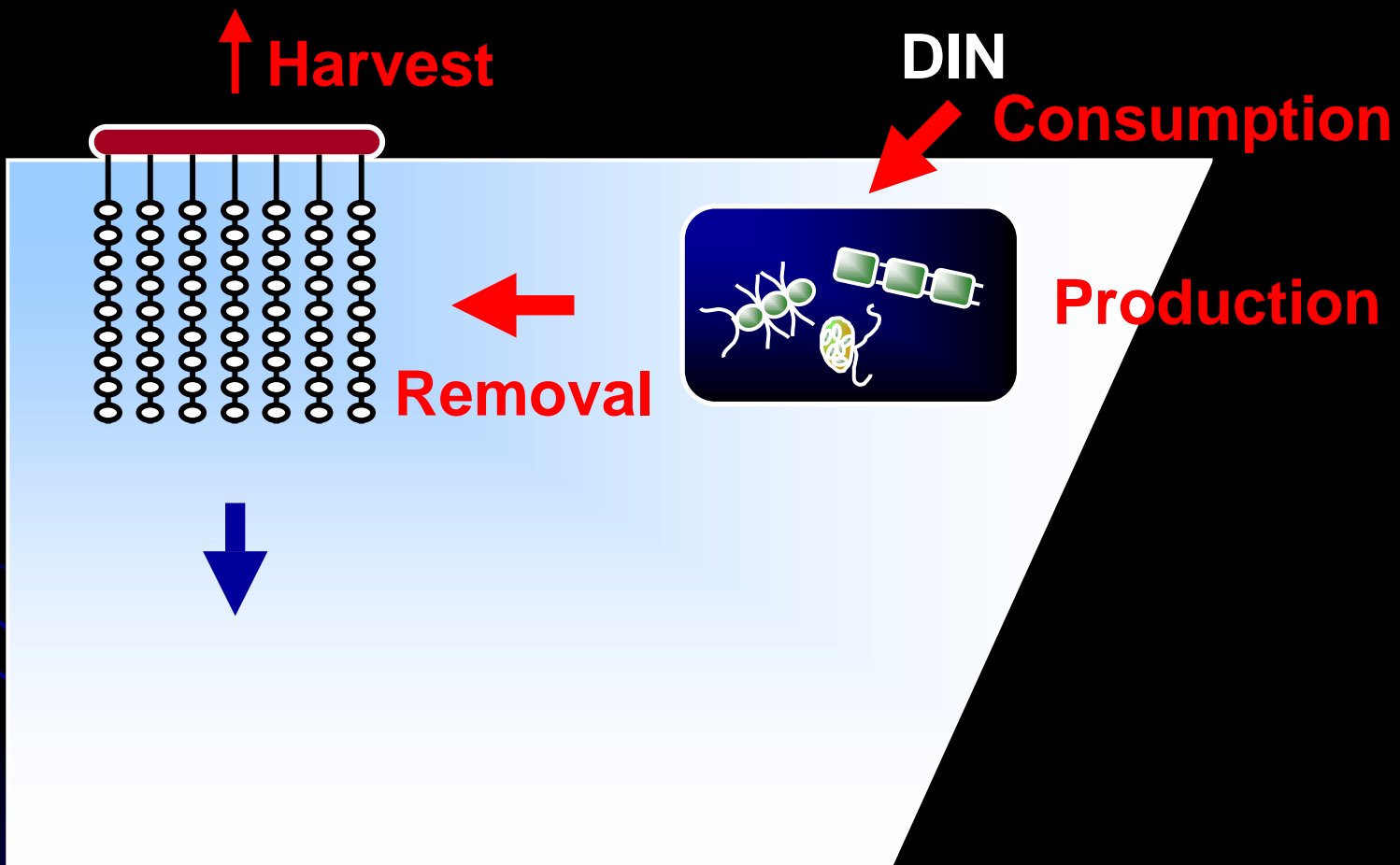
1.5% (DIN)
1.0% (TN)

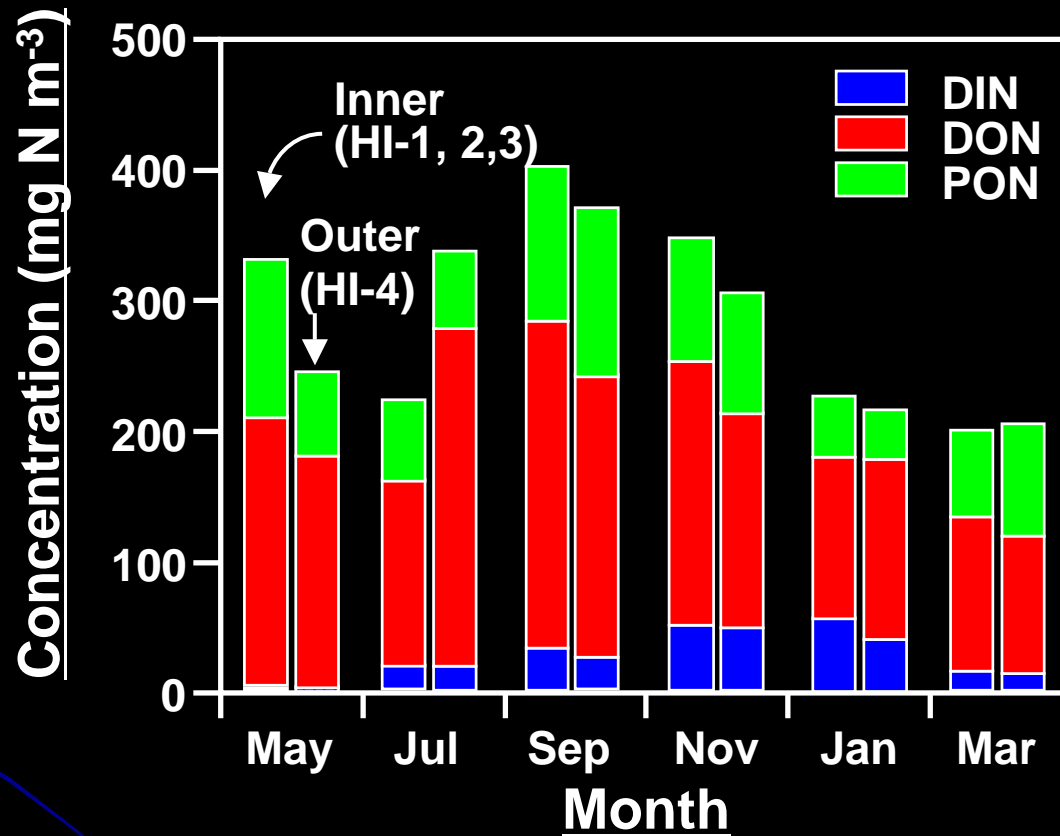
Daily nitrogen input from land (annual mean):
10.3 ton N d⁻¹ (DIN), 14.8 ton N d⁻¹ (TN)

Comparison of the nitrogen removal rates from northern Hiroshima Bay between oyster cultures and fisheries

Conclusion

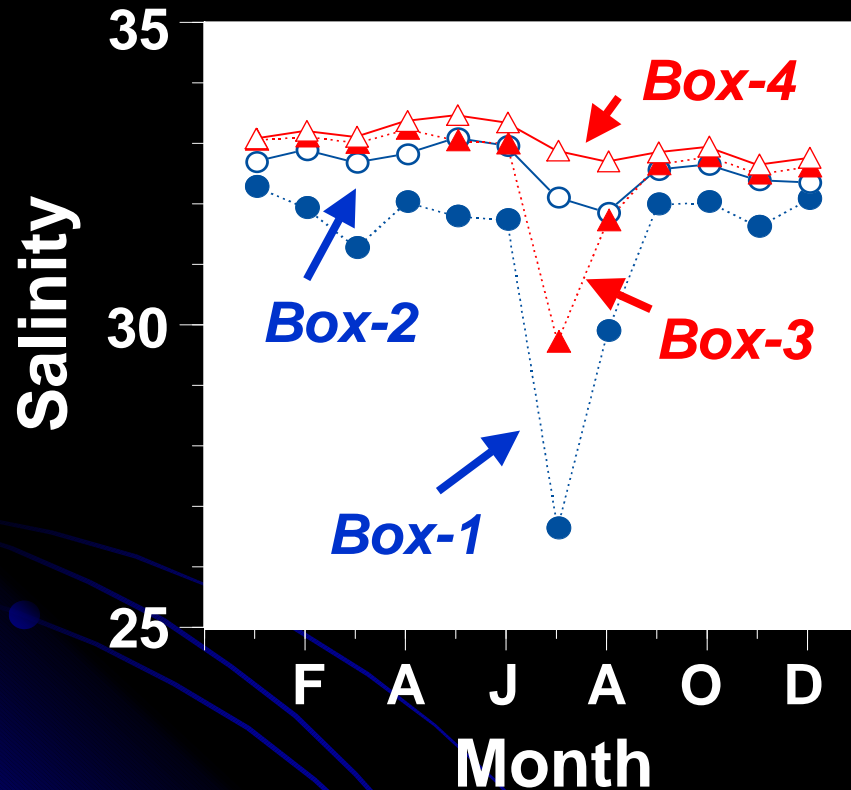
- ◆ **Estimated filtration rate of cultured oysters was 7.3 ton N d⁻¹ (which was corresponding to ca. 20% of primary production), suggesting that the filtering activity of oyster cultures is highly significant (removal of phytoplankton particulate nitrogen from the bay) in considering the nitrogen cycle in Hiroshima Bay.**
- ◆ **The removal rate through oyster harvesting (0.68 ton N d⁻¹) was five times higher than that by fishery activities, suggesting that oyster culture plays a significant role on the recycling of nitrogen from Hiroshima Bay to the land.**



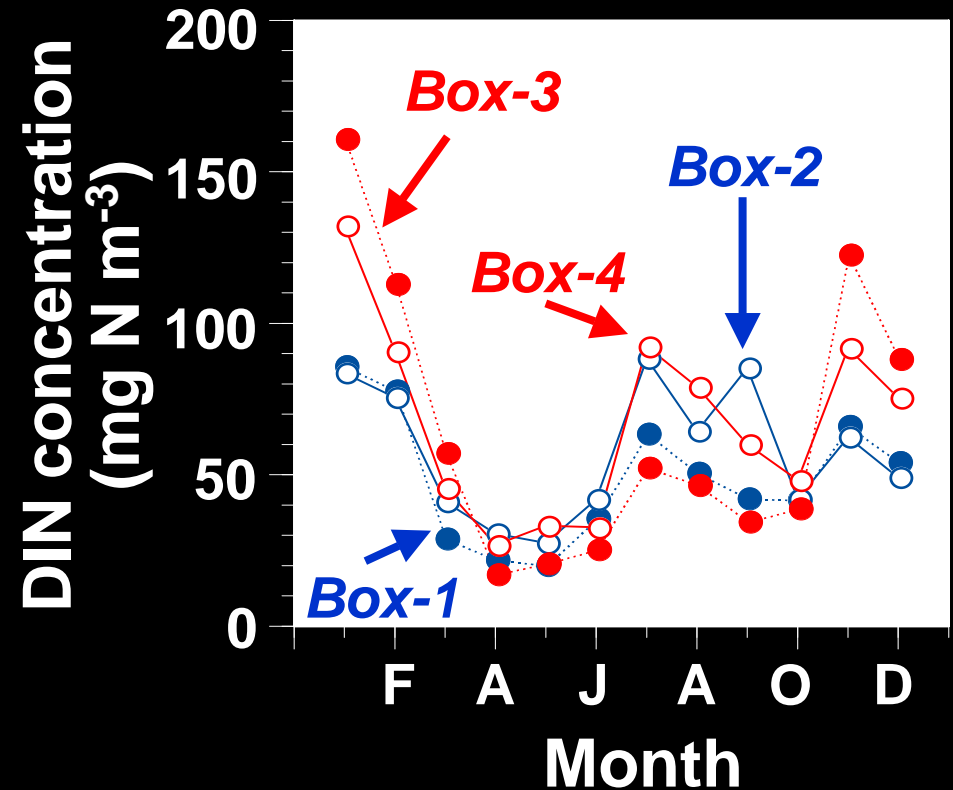


Seasonal changes in dissolved inorganic nitrogen (DIN), dissolved organic nitrogen (DON) and particulate organic nitrogen (PON) concentrations in Hiroshima Bay. Values are depth-weighted water column averages.

Seasonal variations of salinity and nitrogen concentration in each box



Time series of salinity in each box in Hiroshima Bay through Jan – Dec 2001.



Time series of DIN concentration in each box in Hiroshima Bay through Jan – Dec 2001.

Nitrogen cycle in northern Hiroshima Bay

